

College of Arts and Sciences

Dean of Fine Arts, Humanities and Social Sciences

Nancy Kleniewski

Professor of Sociology; A.B., Emmanuel College; M.A., Ph.D., Temple University.

Dean of Sciences

Robert H. Tamarin

Professor of Biological Sciences; B.S., Brooklyn College of the City University of New York; Ph.D., Indiana University.

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The College of Arts & Sciences offers 27 programs of graduate study including Master of Arts, Master of Science, Doctor of Science, and Doctor of Philosophy Degrees in a variety of fields. These degree programs are part of the University's commitment to develop regional and national economies by providing state-of-the-art educational programs beyond the bachelor's degree. A wide range of on-going research and project opportunities exist within the various degree programs, and interdisciplinary study is emphasized. Graduates of these programs are heavily recruited both regionally and nationally by industry and governmental agencies.

MASTER OF ARTS DEGREES (M.A.)

Community Social Psychology
Criminal Justice

MASTER OF SCIENCE DEGREES (M.S.)

Biological Science
 Biotechnology option
Chemistry
Computer Science
Environmental Studies
Atmospheric Sciences Concentration
Mathematics
 Applied Mathematics Option
 Mathematics for Teachers
 Option
 Statistics Option
 Scientific Computing Option
Physics
 Optical Sciences Option
Radiological Sciences and Protection

DOCTOR OF PHILOSOPHY DEGREES (PH.D.)

Chemistry
 Biochemistry Option
 Environmental Studies Option
Physics
Applied Mechanics Option
 Energy Engineering Option
Radiological Sciences
Polymer Science
Polymer Science/Plastics
 Engineering Option

DOCTOR OF SCIENCE (SC.D.)

Computer Science
Mathematical Science Option

DEPARTMENT OF Biological Sciences

Department Chair

Robert D. Lynch

Professor; A.B., Northeastern University; M.S., D.Sc., Harvard School of Public Health.

Graduate Coordinator

Ize B. Skare

Associate Professor; B.A., University of Connecticut; Ph.D., Duke University.

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Garth F. Hall

Assistant Professor; B. Sc., McGill University; Ph.D., Yale University.

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Robert Tamarin

Professor and Science Dean of the College of Arts and Sciences; B.A., Brooklyn College; Ph.D., Indiana University.

The following degree programs are available: Master of Science in Biological Sciences; Master of Science in Biological Sciences - Biotechnology Option; Doctor of Philosophy in Chemistry - Biochemistry Option (through a joint program with the Department of Chemistry- see description in Chemistry section).

A Graduate Certificate in Biotechnology and Bioprocessing, offered by the Massachusetts Bioprocess Development Center, is administered jointly by the Departments of Biological Sciences and Chemical and Nuclear Engineering (more information follows the degree program descriptions).

Research and Teaching Facilities

The Departmental research and teaching instrumentation includes an array of centrifuges (ultraspeed, superspeed, microfuges), electrophoresis equipment (prep and analytical for proteins and nucleic acids, sequencing, isoelectric focusing, pulsed-field), PCR thermal cyclers, HPLC perfusion and other chromatography equipment; UV-visible and fluorescence spectrophotometers, scintillation spectrometers, various microscopes (transmission EM, fluorescence, inverted phase), microinjection apparatus, flow cytometer, Coulter counter, speed vac, electroporator, microtiter plate reader, fermenters, laminar-flow hoods, and numerous incubators, baths, and ovens for cell growth and temperature-controlled reactions. The facilities include dark rooms, X-ray facility, temperature-controlled plant and animal cell culture incubation chambers and walk-in rooms, and animal quarters. Labs and offices have Internet access and extensive computer facilities such as computerized image processing and microdensitometry. Highly specialized equipment in the Center for Advanced Materials in the Chemistry Department, such as transmission and scanning electron microscopes, scanning tunneling-atomic force microscope, secondary ion mass spectrophotometers, and X-ray diffractometers, are available for faculty and student research.

Faculty Research Interests

The graduate faculty in the Department of Biological Sciences are actively engaged in research in the following areas: biochemistry, molecular biology, cell biology, immunology, neuro-

biology, developmental biology, tumor cell biology, and applied and environmental microbiology.

MASTER OF SCIENCE DEGREE PROGRAMS

The Master of Science in Biological Sciences and the Master of Science in Biological Sciences - Biotechnology Option provide the advanced study and training necessary to conduct independent research at a professional level and to be successful in today's competitive academic and industrial research markets. Students in the program will be encouraged to explore quantitative approaches to the solution of problems in the basic and applied biological sciences. Depending on their career goals, students may choose either research or course work options within the Department, or from the interdisciplinary Biotechnology option. All candidates for the master's degree are expected to demonstrate sufficient knowledge and skills to pursue independent and creative research activities.

Entrance Requirements and Procedures

Entering graduate students are expected to have a sound preparation in the biological sciences, chemistry, physics, calculus, and statistics. A student found deficient in any of these areas may be required, during the first year, to take appropriate courses to eliminate the deficiencies. If the student has not had a biochemistry course, 81-519 should be taken for graduate credit. The departmental Graduate Coordinator helps plan the entering students' programs of study, acquaints them with research opportunities in the department, and assists in selecting research advisors.

Degree Requirements

A minimum of 30 semester hours of graduate level work is required for the Master of Science degree in Biological Sciences. The student has a choice of three options: thesis, project, or non-thesis. Minimal core requirements for all options include 2 semesters (4 credits) of Current Literature in Biology and 12 credits of formal course work selected from departmental electives (exclusive of thesis, project, problems, or other directed studies). The remaining 14 credits may be satisfied by additional electives within the department (thesis, project,

problems, or more course work), by transfer credit for approved graduate level biological sciences courses taken at other accredited institutions (12 credit maximum), or by graduate courses taken in related disciplines within the University (e.g., chemistry, environmental sciences, chemical engineering, radiological sciences; 8 credit maximum). There is no formal language requirement. Students whose professional goals are to continue on for the Ph.D. degree, or who plan to seek employment in academic or industrial research laboratories as technicians or junior scientists are strongly advised to choose the thesis or project option in order to successfully compete for such positions. Students in the non-thesis option should endeavor to select courses with accompanying laboratories whenever possible.

Thesis Option

In choosing this option, the student concentrates on an in-depth, independent, scholarly investigation of a contemporary biological problem. Credit is allowed for 6-12 semester hours of M.S. Thesis Research. After consulting with the research advisor, the student selects two additional faculty members (one of whom must be from within the Department) to serve as members of the Thesis Committee. The student presents to the Committee a proposal of intended research and obtains the Committee's approval of the research topic. After completing the written thesis, the student gives an oral presentation of his results to the Thesis Committee.

Project Option

The project option is designed for independent laboratory investigations of a more limited nature than the thesis option. Generally, a project is completed in one or two semesters and credit is given for 3 or 6 semester hours of M.S. Project (no more than 6 credits will be allowed).

Non-Thesis Option

This option offers course work in breadth and depth, and may be of special interest to secondary school science teachers and individuals already employed in academic, hospital, or industrial laboratories. The non-thesis option may be completed during the day on a full-time basis or in late-afternoon or evening sessions on a part-time basis. However, since not all day courses are

available in the evening sessions, a part-time student's progress toward the M.S. degree will depend not only on his/her available time and abilities, but also on the scheduling of electives. In some instances, with the consent of a faculty member, an evening student may elect the thesis or project option.

Professional Experience

Credit (81-500; 3cr) may be requested by individuals who present satisfactory evidence (in the form of a written statement from their supervisor) of having at least one year of full-time experience in secondary school science teaching, or in an academic, hospital, or industrial laboratory setting.

Current Literature in Biology

Each student is required to complete 2 semesters of Current Literature in Biology.

M.S. IN BIOLOGICAL SCIENCES - BIOTECHNOLOGY OPTION

This option is more structured than the M.S. in Biological Sciences program described above. The core curriculum offers extensive hands-on experience in current techniques and instrumentation. Field trips and seminars afford students an opportunity for interaction with the biotechnology industry. Students are encouraged to conduct research in one of the recognized areas of biotechnology or to present an innovative application of technology or engineering principles to a biological problem of economic interest. The nature and extent of the investigation will determine its degree credit value. Those who enter the program having already completed some of the core courses, or who already have extensive laboratory experience, may consult with an advisor to design a course of study appropriate to their needs. A variety of biotechnology-related electives are available.

Core Requirements Biotechnology Option

81.519	Biochemistry I
81.520	Biochemistry II
81.521	Techniques in Biochemistry
81.567/569	Recombinant DNA Techniques (lecture and lab)

81.576/578	Cell Culture (lecture and lab)
81.593/595	Immunology (lecture and lab)
81.706	Current Literature in Biology

Recommended Electives- Biotechnology Option

81.535	Principles of Cell and Microbe Cultivation
81.546	Isolation and Purification of Biotech Products
81.555	Biopharmaceutical GMP and Licensing
81.558	Industrial Microbiology
81.572/574	Virology Lecture and Lab
81.586	Biotechnology Processing Projects Laboratory
81.733	M.S. Project in Biology

Courses from other Departments may be elected with permission of the Biological Sciences Chairman or Graduate Coordinator. The sum of core and elective courses must total at least 30 credits.

FIVE YEAR B.S./M.S. PROGRAM

Outstanding undergraduates may pursue an accelerated five-year course of study leading to the B.S. and M.S. degrees in Biological Sciences. See description at the front of this catalog for further information.

DOCTOR OF PHILOSOPHY DEGREE PROGRAM (PH.D IN CHEMISTRY- BIOCHEMISTRY OPTION)

The Department of Biological Sciences and the Department of Chemistry have developed a program in Biochemistry which results in the award of a Ph.D. in Chemistry. For a full discussion of program requirements please see the section on Biochemistry under the Chemistry section of this catalog.

GRADUATE CERTIFICATE IN BIOTECHNOLOGY AND BIOPROCESSING

This graduate certificate is offered jointly by the Department of Biological Sciences and the Department of Chemical and Nuclear Engineering. The Certificate is aimed at students who hold a baccalaureate degree in science, engineering, health, or related disciplines. It may also be attractive to a person currently enrolled in a graduate degree program, as well as to someone holding a master's or doctoral degree who wishes to add or enhance his or her competency in biotechnology and bioprocessing, but does not wish to take another advanced degree. The core sequence of courses emphasizes biological and engineering principles, process concepts and the application of these to process design and improvement. The lecture and laboratory approach is supplemented by case studies and design projects that teach specific principles. Individual courses deliberately cross disciplinary barriers. This allows those with a background in the sciences to gain facility with the engineering approach to problem solving, and permits engineers to learn and apply biological principles. Concurrently, participants learn teamwork in a multidisciplinary environment and practice a result-oriented, document-driven approach to efficient project completion.

The Certificate is composed of four core courses specified below. The fourth course may be chosen from a list of eligible options and the selection requires the approval of the program advisor. Certificate requirements involve completion of the four courses with a 3.0 average and no more than one course with a grade of C. The four course program must be completed within a 5 year period. The core courses are offered at convenient times in order to minimize conflict with regular work schedules.

Applicants will be considered following receipt of an application form available through the Graduate School. Applicants not presently matriculated must submit an official transcript demonstrating completion of a bachelor's degree in science, engineering, or a related discipline. There is no GRE or language requirement.

The courses for the Certificate may be used toward a graduate degree in either Biological Sciences or Chemical and Nuclear Engineering subject to the approval of the graduate coordinator. A grade of B or better is required for use toward a graduate degree. Qualified students may thus count the four core courses toward both the Graduate Certificate and a graduate degree.

Required Courses:

1. Principles of Cell and Microbe Cultivation (81.535/10.535)
2. Isolation and Purification of Biotech Products (81.545/10.545)
3. Biotechnology Processing Projects Laboratory (81.586/10.586)
4. One course from the list below, or another with permission of the department's program advisor.

Approved courses:

- 81:542, 555, 558, 567/569, 572/574, 576/578, 593/595
10:516, 518, 522, 528, 530, 555

Titles and descriptions of 81-prefix courses are listed below. For titles and descriptions of 10-prefix courses see the appropriate section of the Graduate Catalog under Department of Chemical and Nuclear Engineering.

COURSE DESCRIPTIONS

81.500 Professional Experience (3-0)3

Credits will be given to individuals who present evidence of having at least one full year of experience in an academic, hospital, or industrial laboratory setting, or in secondary school science teaching.

81.501, 502 Selected Topics in Biology (3-0)3, (3-0)3 Current topics in various fields of biology presented in lecture, seminar, or discussion groups. Subject matter varies depending on interests of instructors and needs of students. May be repeated for credit when course content differs. Recent offerings have included photobiology and photoreceptors, endocrinology, hormones and receptors, protein biochemistry, industrial cell culture, readings in advanced pathophysiology, and experimental hematology.

81.535 Principles of Cell and Microbe Cultivation (3-0)3 An in-depth examination is made of microbial and mammalian cell cultivation and concomitant production of commercially important products. Systems studied include the use of recombinant and nonrecombinant microbes and mammalian cells to produce proteins, antibiotics, vaccines and other bioproducts having therapeutic, diagnostic, or other commercial significance. Topics run from initial choice of producer through scaleup.

81.541 Advanced Topics in Cell Biology (3-0)3 Prerequisite: Biochemistry. A seminar-format course that examines detailed aspects of various topics in cell biology including cell signalling, signal transduction, cytoskeleton, protein interaction and modifications, cell division, and the extracellular matrix. Introductory overview lectures will be expanded on by critical examination of recent publications. Students will give a 30

min. comprehensive presentation on current developments in an area of their choice subject to instructor approval. Prior courses in biochemistry and cell biology are strongly recommended as we will focus on advanced aspects rather than basic.

81.542 Cell Biology (3-0)3 Prerequisite: Biochemistry Ultrastructure and biochemistry of eukaryotic cells: cell membranes and organelles; energy capture and transduction; histochemical and biochemical studies of organelles at the optical and electron microscopic level; cytogenetics; brief discussion of prokaryotic cells. A substantial library investigation is required.

81.545 Isolation and Purification of Biotech Products (3-0)3 This course examines the efficient isolation and purification of biological products, especially proteins, from complex natural mixtures. Material is presented in a lecture and case-study format using purification and formulation of specific biomolecules. Students work in teams on design projects.

81.519 Principles of Biochemistry I (3-0)3 Prerequisite: Organic Chemistry (Physical Chemistry is recommended). Primarily for M.S. students in Biological Sciences. Lectures and text assignments on the subjects of protein, carbohydrate, lipid, enzyme and membrane biochemistry will be supplemented with research journal readings.

81.520 Principles of Biochemistry II (3-0)3 Prerequisite: 81-519 or equivalent. This course is a continuation of 81-519 and will include discussions on all aspects of amino acid and nucleic acid metabolism and protein biosynthesis.

81.521 Techniques in Biochemistry (1-4)2 Prerequisite/co-requisite: Biochemistry Required of M.S. students in the Biotechnology Option. Emphasis on common techniques and instrumentation employed in modern research laboratories.

81.555 Biopharmaceutical GMP and Licensing (3-0)3 This course examines how "drugs", "biologics" and "cellular therapies" are evaluated, manufactured and sold in the United States. cGMP's, clinical trials, INDA, NDA, ANDA, PLA, ELA, validation, Q.A., Q.C., interactions with FDA staff and with company product and process development, regulatory affairs, drug metabolism, medical affairs, and production are covered in a lecture and project format.

81.558 Industrial Microbiology (3-0)3 Selected topics concerned with the use of microorganisms for the production of substances of economic importance. The principles and techniques of fermentation to produce such products as amino acids, antibiotics, vitamins, and organic acids are addressed, with emphasis on metabolic regulation of biochemical pathways and genetics of industrially important microorganisms.

81.563 Electron Microscopy - Theory and Practice (2-6)4 Prerequisites: Biochemistry

and permission of instructor. Introduction to electron optics and electron microscopes. Preparation of biological samples for electron microscopy. Operation of electron microscopes. Project required of all students.

81.567 Recombinant DNA Techniques (3-0)3 Prerequisites: Genetics, Biochemistry Co-requisite: 81-569. A study of the principles and specialized techniques of cloning, purifying, and manipulating recombinant DNA molecules. A term paper or seminar may be required.

81.569 Recombinant DNA Techniques Laboratory (1-4)2 Co-requisite: 81.567, permission of instructor. Laboratory experiments and independent projects designed to illustrate current techniques and instrumentation used in genetic engineering. Included are restriction digestion and mapping, cloning, plasmid purification, Southern blotting, PCR, and DNA sequencing. Students use various computer software programs for restriction digest and DNA sequence manipulation and analysis, and graphic presentation of recombinant constructs.

81.572 Virology (3-0)3 Prerequisites: Genetics and Biochemistry. A study of bacterial, animal, and plant viruses, including viral structure, modes of replication, biochemistry of the infected cell, genetic properties, and viral oncogenesis. Emphasis is on virus-cell interaction at the molecular level. A term paper or seminar is required.

81.574 Virology Laboratory (1-4)2 Experiments with bacterial and animal viruses include lytic virus propagation and titering, biochemical, biophysical, and genetic analysis of viral nucleic acids and proteins, and cell culture techniques.

81.576 Cell Culture (2-0)2 Prerequisites: Genetics, Biochemistry, Immunology Co-requisite: 81-578. Lectures and readings on the biology and culture of animal and plant cells in vitro, the specialized methodologies necessary for hybridoma technology, and the biotechnological applications of each of these areas. A term paper or seminar is required.

81.578 Cell Culture Laboratory (1-4)2 Co-requisite: 81-576 A series of exercises demonstrating the principles presented in 81-576. Techniques will include: media preparation, standard culture procedures and hybridoma methodology.

81.580 Developmental Biology (3-0)3 Prerequisites: Genetics, Biochemistry. A study of the genes, growth factors and events which regulate the development of a fetus. The construction of the mammalian embryo is examined, from fertilization to birth. Lectures and original research papers are used to learn about cell fate determination, cell-cell interactions during organ formation, and the molecular biology of developmental processes.

81.586 Biotechnology Processing Projects Laboratory (2-3)3 This laboratory course examines bioprocessing, with emphasis on

techniques for the cultivation of cells, recovery and purification of cell products, biocatalysis, and analytical methods for the quantification of product yields.

81.593 Immunology (3-0)3 Prerequisites: Microbiology, Genetics, Biochemistry. A study dealing with the nature of the immune response with sections on antibody structure, function and production; antigen-antibody reactions; immunogenetics; and immune regulation, protection and injury.

81.595 Immunology Laboratory (1-4)2 A series of basic laboratory exercises dealing with the preparation, isolation and characterization of antigens, antibodies and effector cells. Semester project required.

81.706 Current Literature in Biology (2-0)2 Participants are required to present 2 seminars per semester: a short talk on an assigned journal article or topic, and a lecture-length presentation on an advanced topic or their own original research. A fully documented report must accompany the long seminar. Students are also graded on active participation in discussions and will critique each other's presentations. M.S. students are required to enroll twice for this course.

81.711,712 Graduate Topics in Biology (3-0)3, (3-0)3 Prerequisite: Graduate students only; permission of instructor. Selected topics and recent advances not covered in regular courses. Content varies from year to year so that students may, by repeated enrollment, acquire a broad knowledge of contemporary biology.

81.721, 722, 723 Problems in Biology (0-3)1 to (0-9)3 Prerequisite: permission of instructor. Special research or laboratory projects, or extensive literature surveys, undertaken by the student to expand his/her knowledge in specific fields.

81.733,736 M.S. Project in Biology (0-9)3 or (0-18)6 An independent laboratory project which has been approved by a research advisor as a suitable subject for a Master's Project.

81-743,746,749 M.S. Thesis (0-9)3 to (0-27)9 An in-depth independent investigation of a problem which has been approved by the student's research mentor as a suitable subject for a Master's Thesis.

81.753,756,759 Ph.D. Dissertation (0-9)3 to (0-27)9 Thesis research by Ph.D. students who are in the joint Biochemistry Program Option (between the Chemistry and Biological Sciences Departments) and are conducting research with faculty in Biological Sciences.

DEPARTMENT OF CHEMISTRY

Department Chair

Edwin G.E. Jahngen

Professor; B.S., Bates College; Ph.D., University of Vermont.

Faculty

Anastasios P. Angelopoulos

Assistant Professor; B.S., M.S., Tufts University; Ph.D., Princeton University.

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Nancy DeLuca

Associate Professor; B.S.; Queens College; M.S., Ph.D., Ohio State University.

Rudolf Faust

Professor; M.S., Ph.D., Eotuos Lorand University of Sciences, Budapest, Hungary.

Martin Isaks

Associate Professor; B.S., Purdue University; M.S., Iowa State University; Ph.D., University of Cincinnati.

Albert D. Kowalak

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